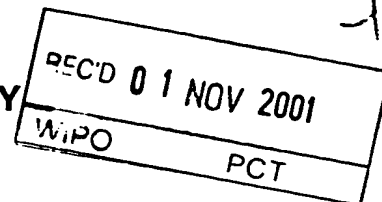


PATENT COOPERATION TREATY

PCT



INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference WO 800163-A1	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/NL00/00659	International filing date (day/month/year) 18/09/2000	Priority date (day/month/year) 17/09/1999
International Patent Classification (IPC) or national classification and IPC B03B5/10		
Applicant TECHNISCHE UNIVERSITEIT DELFT		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 5 sheets, including this cover sheet.
 - ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of 4 sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☒ Certain defects in the international application
- VIII ☐ Certain observations on the international application

Date of submission of the demand 11/04/2001	Date of completion of this report 30.10.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Leitner, J Telephone No. +49 89 2399 7924 <div style="text-align: right;"> </div>

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/NL00/00659

I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

Description, pages:

1-10 as originally filed

Claims, No.:

1-20 as received on 10/10/2001 with letter of 09/10/2001

Drawings, sheets:

1/4-4/4 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/NL00/00659

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims 1-20
	No: Claims
Inventive step (IS)	Yes: Claims 1-20
	No: Claims
Industrial applicability (IA)	Yes: Claims 1-20
	No: Claims

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

Re Item V:

Apparatus claims: US-A-2708032 discloses an apparatus according to the preambles of claims 12,14 and 16.

Differences: **Arrangement** of the separation chamber dividing element with regard to the supply and discharge openings of the separation chamber and the **specific design** of that element in accordance with the specific arrangement, as in the characterizing parts of claims 12,14 and 16.

US-A-4772384 discloses a separator with a rotating element, but arranged and designed differently.

Method claims: US-A-4119533 discloses a method according to the preambles of claims 1,18 and 20.

Differences: In claim 1 a **barrier above the particles for restraining** the particles is used, which has the effect of better particle stratification leading to streams of enriched particles having different densities.

Claims 18 and 20 are using the new and inventive apparatuses as claimed for separating particles in a fluid medium having a density higher than that of the particles.

The separation in US-A-2708032 is based on the size (thickness) of the particles, where the fluid medium has a density much lower than that of the particles and the barrier is not particle restraining and not rotating.

The method of US-A-4119533 is based on the hydrophobicity of the materials, and not by using the steps set out in claims 1,18 and 20 or by using an apparatus as claimed in 12,14 or 16.

Therefore, the subject matter of claims 1,12,14,16,18 and 20 meet the requirements of Article 33 (2), (3) PCT.

The dependent claims 2-11,13,15,17 and 19 concern particular embodiments of the independent claims, respectively, and likewise meet the requirements of Article 33 (2), (3) PCT.

The industrial application is obvious.

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/NL00/00659

Re Item VII:

The dependency of claim 18 must be changed to ".....according to claim 16.....".

The dependency of claim 20 must be changed to ".....according to claim 17.....".

Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in the documents US-A-2708032 and US-A-4119533 is not mentioned in the description, nor are these documents identified therein.

The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).

10. 10. 2001

CLAIMS

(52)

1. Method of separating particles in a fluid medium having a density higher than that of the particles to be separated, whereby a mixture of the particles to be separated is fed to a separation chamber of a separation apparatus, and
5 streams enriched in a particular type of particles are discharged from the separation chamber, characterized in that the mixture of particles is subjected to a treatment comprising the step of moving the fluid medium up and down relative to the mixture of particles, whereby a barrier is present
10 above the particles for restraining the particles.

2. Method according to claim 1, characterized in that the particles to be separated are plastic particles.

3. Method according to claim 2, characterized in that the plastic particles to be separated are polyolefines.

15 4. Method according to any of the preceding claims, characterized in that the fluid medium is an aqueous medium.

5. Method according to claim 4, characterized in that the aqueous medium is water.

20 6. Method according to claim 4 or 5, characterized in that the aqueous medium has a temperature of about 0°C.

7. Method according to any of the preceding claims, characterized in that separate discharge-facilitating particles are present in the fluid medium.

25 8. Method according to claim 7, characterized in that facilitating particles are bulky particles having a density between the densities of the streams enriched in particular particles.

30 9. Method according to any of the preceding claims, characterized in that the barrier for restraining the particles is an element provided in the separation chamber.

10. Method according to any of the preceding claims, characterized in that the element for restraining the particles comprises passages for the passage of the fluid medium.

35 11. Method according to any of the preceding claims, characterized in that the element is provided at an angle

with the horizontal, preferably at an angle between 2 - 45°, more preferably between 5 - 30° such that the particles are transported away from the place of supply.

12. Apparatus suitable for separating particles having a density lower than that of a fluid medium, wherein the apparatus comprises
- a separation chamber having a supply opening for particles to be separated;
 - discharge openings for separated fractions of particles;
 - 10 - an element possessing passages provided above the supply opening, the element defining a first portion of the separation chamber and a second portion of the separation chamber;
 - means for moving a fluid medium up and down relative to the particles to be separated,
 - 15

characterized in that the element is a particles restraining element, and supply opening and the discharge openings are in direct communication with each other via the first portion.

13. Apparatus according to claim 12, characterized in that the element is provided at an angle with the horizontal, preferably an angle between 2 - 45°, more preferable between 5 - 30.
- 20

14. Apparatus suitable for separating particles having a density lower than that of a fluid medium, wherein the apparatus comprises
- 25

- a separation chamber having a supply opening for particles to be separated;
- discharge openings for separated fractions of particles;
- an element possessing passages provided above the supply opening, the element defining a first portion of the separation chamber and a second portion of the separation chamber;
- 30 - means for moving a fluid medium up and down relative to the particles to be separated,

- 35 characterized in that the element has a first section with first passages and a second section with second passages, the first passages being smaller than the second passages, the first section being a particles restraining element, a supply

opening and a first discharge opening being in direct communication with each other via the first portion, the supply opening and a second discharge opening being in communication with each other via the first portion, the second section and
5 the second portion.

15. Apparatus according to claim 14, characterized in that the element is provided at an angle with the horizontal, preferably an angle between 2 - 45°, more preferable between 5 - 30.

10 16. Apparatus suitable for separating particles having a density lower than that of a fluid medium the apparatus comprises

- a separation chamber having a supply opening for the particles to be separated;
- 15 - an element provided above the supply opening, said element comprising a multitude of openings allowing the passage of said particles; and
- means provided to move the fluid medium up and down relative to the particles to be separated,
- 20 characterized in that said supply opening extends in a substantially radial direction and second means are provided to rotate the element relative to fluid medium in the separation chamber.

17. Apparatus according to claim 16, characterized
25 in that it comprises means for locally disturbing a mass comprising added particles not capable of passing through the openings of said element and particular particles separated from particles which have passed through said openings of said element.

30 18. Method of separating particles in a fluid medium having a density higher than that of the particles to be separated, characterized in that an apparatus according to claim 14 is used, a mixture of particles to be separated is supplied below a layer of particles having a thickness which
35 doesn't allow them to pass through the openings of the element, the fluid medium in the separation chamber is rotated relative to the element, the element is moved up and down to move the fluid medium relative to the particles to be sepa-

rated, causing particles with lower density to pass through the facilitating particles and through the openings in said element to end up in fluid medium above said element from which the particles are discharged from the separation chamber, whereas the facilitating particles act as a barrier for and restrain the particles with higher density, which particles with higher density are discharged from the separation in the fluid medium below said element.

19. Method according to claim 18, characterized in that the fluid medium is rotated with respect to the wall of the separation chamber.

20. Method of separating particles in a fluid medium having a density higher than that of the particles to be separated, characterized in that an apparatus according to claim 16 is used, a mixture of particles to be separated is supplied below a layer of particles having a thickness which doesn't allow them to pass through the openings of the element, the fluid medium in the separation chamber is rotated relative to the element, the element is moved up and down to move the fluid medium relative to the particles to be separated, causing particles with lower density to pass through the facilitating particles and through the openings in said element to end up in a first section comprising fluid medium above said element from which first section the particles are discharged from the separation chamber, whereas the facilitating particles act as a barrier for and restrain the particles with higher density, the means for locally disturbing the mass of facilitating particles and restrained particles with higher density, allowing said particles with higher density to pass through the openings in said element to end up in a second section above the element separated from the first section and discharging a stream enriched in particles having a higher density from the separation chamber.

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(19) World Intellectual Property Organization
International Bureau



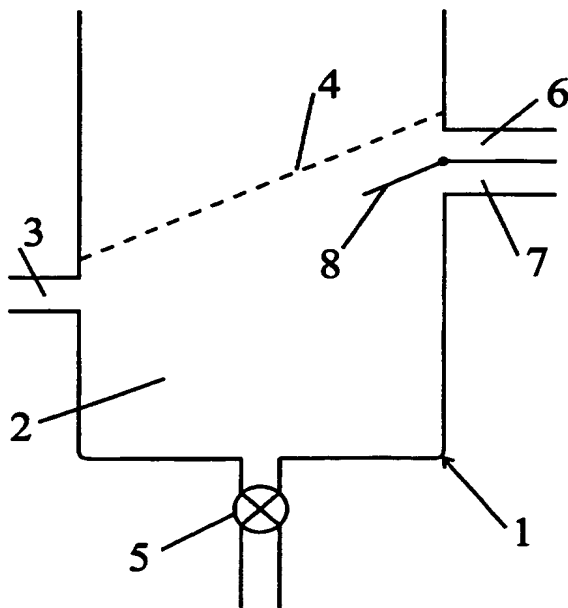
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(54) Title: METHOD OF SEPARATING PARTICLES IN A FLUID MEDIUM AND AN APPARATUS THEREFOR



(57) Abstract: The invention relates to a method of separating particles in a fluid medium, wherein the particles have a density lower than that of the fluid medium. According to the invention the particles are subjected to an up and down moving flow of the fluid medium, whereby a barrier is present above the particles restraining said particles. It appears that with the method according to the invention a particle separation can be performed in a cost effective and quick manner. The invention is in particular suited for the separation of plastics, such as polyethylene and polypropylene. The invention also relates to an apparatus suitable for performing the method.

WO 01/21317 A1

Method of separating particles in a fluid medium and an apparatus therefor

The present invention relates to a method of separating particles in a fluid medium having a density higher than that of the particles to be separated, whereby a mixture of the particles to be separated is fed to a separation chamber of a separation apparatus, and streams enriched in a particular type of particles are discharged from the separation chamber.

The use of a fluid medium for the separation of a mixture of particles in two or more fractions is generally known. When the particles have a specific density lower than that of the fluid medium, such a separation is not very easy. It is known in the art to use centrifugation in order to increase the effect of the difference in density between the types of particles. This technique is expensive and often results in an unsatisfactory separation.

The object of the present invention is to provide a method wherein mixtures comprising different types of particles can be separated adequately.

To this end, the method according to the present invention is characterized in that the mixture of particles is subjected to a treatment comprising the step of moving the fluid medium up and down relative to the mixture of particles, whereby a barrier is present above the particles for restraining the particles.

Surprisingly it has been found that moving a mixture of particles having a density lower than that of the fluid medium up and down relative to said fluid medium (also known as "jigging") may effect stratification to achieve a separation. Jigging has been known for decades but not for the separation of particles having a density lower than that of the surrounding fluid medium. The mixture may comprise, for example, cork or wood. It may also be a mixture derived from domestic refuse. The barrier present for restraining the particles may be the face of the fluid medium. A stream enriched in particles of a particular type comprise the fluid medium

and the particular particles. The separation according to the present invention will result in (at least) two streams: A first stream enriched in first particles having a density lower than that of the fluid, and a second stream enriched in second particles having a density lower than that of the fluid.

According to an important embodiment, the particles to be separated are plastic particles.

The separation of plastics is a very important application for which, indeed, currently a number of different techniques is available, but which all suffer from one or more important disadvantages. For example, it is known to separate particles electrostatically, (which method is very sensitive to the presence of humidity), measuring particles individually using infrared light, (which method is slow and expensive), performing a float-sink separation in a hydrocyclone or using water-air suspensions. The separation of plastics makes it possible to obtain higher grade plastics which can be used for the manufacture of new plastic products. In addition, the use of compatibilizers is substantially avoided or even unnecessary. This not only entails a savings in cost, but also the plastic product manufactured from the recycled material is of higher quality, and can be re-used more often.

According to an important embodiment, the plastic particles are polyolefines.

Using the method according to the present invention, a separation may be performed quickly and efficiently even with very similar plastics, such as polyethylene and polypropylene.

According to an important embodiment, the fluid medium is an aqueous medium, in particular water.

The use of aqueous media and in particular water, which are very cheap fluid media, does not result in contamination of the streams enriched in a particular type of particles and do not discharge volatile organic compounds (or just to a reduced extent). When using an aqueous medium such as water for the separation of plastics, care should be taken that the particles are well wetted by the fluid medium in or-

der to prevent adherence of air bubbles (which cause a false change in the density of the particle). This may be accomplished using friction-washing with the fluid medium or by adding low concentrations of surfactants. It is also possible to perform the method under elevated pressure (as a result of which any air bubbles present dissolve), or under reduced pressure (resulting in larger air bubbles which can more easily escape, after which the method is preferably again performed at ambient pressure).

According to an important embodiment, the aqueous medium has a temperature of about 0°C.

At this temperature the ratio of the densities of plastics to be separated, such as polyethylene and polypropylene, is maximal.

According to an important embodiment, separate discharge-facilitating particles are present in the fluid medium.

The presence of facilitating particles may be of particular importance when the composition of the mixture varies. By placing a partition substantially in the middle of the layer of the facilitating particles, the achievement of an optimal separation may be ensured. The facilitating particles may be separated from a stream enriched with a particular type of particles by any suitable means, such as the use of magnetism if the facilitating particles are ferromagnetic. Of course, facilitating particles recovered will be fed back into the separation chamber.

In this manner the separation of two types of particles may be optimised. It is also conceivable that more layers of facilitating particles are formed between (for example three) different types of particles.

Preferably the facilitating particles are bulky particles having a density between the densities of the streams enriched in particular particles.

This embodiment is very advantageous when the particles to be separated are flakes. The bulky particles will experience an effective density of its surrounding determined by both the density of the fluid medium and the particles

present. The different shape of the particles to be separated on the one hand and the facilitating particles on the other, makes it very easy to separate the facilitating particles from a stream enriched in a particular type of particle. The
5 bulky facilitating particles may have a largest size similar to that of the largest particles to be separated, but its thickness will be significantly more than that of the particles to be separated, such as at least five times more. Advantageously the bulky particles are, for example, approximately
10 spherical particles, cylindrical particles or polygonal bodies such as cubes etc.

Preferably an element provided in the separation chamber is used as the barrier for restraining the particles in the separation chamber.

15 Such an element makes it easy to generate the up and down moving flow of fluid medium while causing a minimal disturbance of particle layers already partially separated.

Preferably the element for restraining the particles comprises passages for the passage of the fluid medium.

20 As such an element a sieve or grating is suitable, the openings of which will suitably, be smaller than the smallest particles of the mixture.

Preferably the element is at an angle with the horizontal, preferably at an angle between 2-45°, and more preferably between 5-30°, 5-20° being most preferred, such that
25 the particles are transported away from the supply opening. This aids in the transport of the particle layers in the separation chamber.

The invention also relates to a device suitable for
30 separating particles having a density lower than that of the fluid medium.

Such an apparatus is characterized in that the apparatus comprises a separation chamber having a supply opening for particles to be separated and an element provided above
35 the supply opening for restraining said particles, which apparatus is further provided with means for moving a fluid medium up and down relative to the particles to be separated.

Using such an apparatus makes it possible to achieve

an efficient separation of the particles in a cheap and simple manner. The element and the means for moving the fluid medium up and down may be the same, that is a sieve (or screen).

5 Preferably the element comprises openings for the passage of a fluid medium.

Such an element may suitably be a sieve of grating, of which the openings will suitably, be smaller than the smallest particles of the mixture.

10 According to a preferred embodiment, the element is provided at an angle with the horizontal, preferably at an angle between 2-45°, more preferably between 5-30°, 5-20° being most preferred, such that the particles are transported away from the place where they are supplied.

15 The invention also relates to an apparatus suitable for separating particles having a density lower than that of a fluid medium.

 This apparatus is characterized in that the apparatus comprises a separation chamber having a supply opening
20 for the particles to be separated said supply opening extending in a substantially radial direction and an element is provided above the supply opening, said element comprising a multitude of openings allowing the passage of said particles, first means are provided to move the fluid medium up and down
25 relative to the particles to be separated and second means are provided to rotate the element relative to fluid medium in the separation chamber.

 In operation, the mixture of particles to be separated will be supplied below facilitating particles. The element and the fluid medium may be rotated at the same speed
30 (and in the same direction), allowing a very simple separation operation. The particles with higher density which do not pass the barrier consisting of the facilitating particles may be removed from the separation chamber, for example together with the facilitating particles. The facilitating particles can be separated from the particles with higher density by any conventional method, such as separation by size,
35 using magnetic fields etc.

According to an interesting embodiment, the apparatus comprises means for locally disturbing a mass comprising added particles not capable of passing through the openings of said element and particular particles separated from particles which have passed through said openings of said element.

Thus it is possible to use the element to separate the facilitating particles from the particles having higher density. The means may comprise a pipe provided with a slit or number of nozzles from which fluid medium is ejected.

The invention also relates to a specific method of separating particles in a fluid medium having a density higher than that of the particles to be separated, wherein an apparatus according to the invention is used, a mixture of particles to be separated is supplied below a layer of facilitating particles having a thickness which doesn't allow them to pass through the openings of the element, the fluid medium in the separation chamber is rotated relative to the element, the element is moved up and down to move the fluid medium relative to the particles to be separated, causing particles with lower density to pass through the facilitating particles and through the openings in said element to end up in fluid medium above said element from which the particles are discharged from the separation chamber, whereas the facilitating particles act as a barrier for and restrain the particles with higher density, which particles with higher density are discharged from the separation chamber in the fluid medium below said element.

Preferably, the fluid medium is rotated with respect to the wall of the separation chamber.

According to an alternative method of separating particles in a fluid medium having a density higher than that of the particles to be separated, an apparatus according to an alternative embodiment of the invention is used, a mixture of particles to be separated is supplied below a layer of facilitating particles having a thickness which doesn't allow them to pass through the openings of the element, the fluid medium in the separation chamber is rotated relative to the

element, the element is moved up and down to move the fluid medium relative to the particles to be separated, causing particles with lower density to pass through the facilitating particles and through the openings in said element to end up in a first section comprising fluid medium above said element from which first section the particles are discharged from the separation chamber, whereas the facilitating particles act as a barrier for and restrain the particles with higher density, the means for locally disturbing the mass of facilitating particles and restrained particles with higher density, allowing said particles with higher density to pass through the openings in said element to end up in a second section above the element separated from the first section and discharging a stream enriched in particles having a higher density from the separation chamber.

The present invention will now be illustrated with reference to a drawing and an exemplary embodiment wherein

Fig. 1 depicts a schematic representation of an apparatus according to the invention;

Figs. 2a - d each show a picture of four successive points in time during the separation of particles using the method according to the invention;

Fig. 3 depicts a first alternative schematic representation of an apparatus according to the invention; and

Fig. 4 depicts a second alternative schematic representation of an apparatus according to the invention.

The apparatus 1 shown in Fig. 1 possesses a chamber 2 provided with a supply opening 3 through which a mixture of particles to be separated can be supplied. Above the supply opening 3 a sieve 4 is mounted, the lowest part of the sieve 4 being adjacent to the supply opening 3. In operation, a fluid medium is present in separation chamber 2, which fluid can be moved up and down using a pump 5. For the discharge of separated particles two discharge openings 6, 7 are provided as well as a partition 8 for separating the particle layers. This partition 8 is preferably rotatable, making it easier to subject a mixture in which the ratio of the type of particles varies, to a separation.

It has been found that it is advantageous to increase the resistance with which the fluid medium may flow through the passages of the sieve 4. This may be achieved, for example, by putting a layer of pebbles on top of the sieve 4.

5 If necessary, the mixture of particles to be separated is first subjected to a separation according to particle size, but the method according to the present invention is, in case of flake-shaped particles to be separated, surprisingly insensitive to the diversity of particle size in
10 the mixture.

According to a very interesting embodiment particles to facilitate/separate discharge of different particles are present. According to a first embodiment, these particles will facilitate the division into separate streams of layers
15 comprising a particular type of particle resulting from the separation. A partition can be placed in the layer of facilitating particles. This is much easier than determining the border between two layers comprising different particles. According to a second embodiment, the use of facilitating particles makes it possible to use a barrier having openings al-
20 lowing the passage of the particles to be separated. For example and as schematically depicted in Fig. 3, the openings in sieve section 4a do not allow for the passage of particles. The screen section 4b allows for the passage of lower-
25 density particles (which are discharged from the separation chamber 2 through outlet 13 shown in fig. 4), whereas higher-density particles, which are not capable of penetrating the layer of facilitating particles, will pass through openings in sieve section 4c and are discharged from the separation
30 chamber 2 through outlet 14 (shown in fig. 4).

The apparatus shown in fig. 4 (top view) comprises a circular screen 4 (shown in part) which retains facilitating particles having density chosen such that they end up between particles having a relative low density and particles having
35 a relative high density. The mixture of particles to be separated is supplied in a substantially radial direction through a supply tube 9 having a slit-like supply opening 3 or a multitude of supply openings 3 distributed over a substantial

part of the length of the supply tube 9. Both the screen 4 and the fluid medium in the separation chamber 2 are rotated counter-clockwise. This may be accomplished using a water jet. According to an alternative embodiment, the rotating
5 screen 4 causes the fluid medium to rotate. To avoid a detrimental effect because of turbulence near the wall of the separation chamber, the screen 4 may be provided with circumferential, downward extending wall (not shown, but similar to fig. 3 near supply opening 3), the wall having a height
10 larger than the length of stroke during operation.

In operation, particles having a lower density will pass through the layer of facilitating particles and through openings in the screen 4. A stream comprising fluid medium and particles having a lower density may be discharged from
15 the separation chamber 2 from above the screen 4. The facilitating particles act as a barrier for the particles having a relatively higher density. The latter particles may be removed from below the screen 4 together with (a part of) the facilitating particles. Any facilitating particles present in
20 a stream enriched in particles having a higher density may be separated using any conventional means, and will be fed back into the separation chamber 2 below the screen 4.

Alternatively, the screen 4 may be used to separate the denser particles from the facilitating particles by disturbing the strata (facilitating particles and denser particles). This may be easily achieved using pipes 12 provided with nozzles which supply fluid medium to disturb the subtle balance in the strata, causing the denser particles to go through the screen 4. In this case, two separate sections 10,
25 11 are provided above the screen 4. Both sections 10, 11 may move up and down together with the screen, but do not rotate. The first section 10 is used to collect particles having a lower density, the second section 11 is used to collect particles having a higher density.
30

35

Example 1

A mixture was prepared of 0.8 kg HDPE (white: density 945 kg/m³) and 0.2 kg PP (blue, density 900 kg/m³). The

grain size of both types of plastic was 1.7 - 4 mm. The apparatus used had a separation chamber with a volume of 3.1 litre and a diameter of 19 cm. Water was used as the fluid medium. To separate, the water was moved up during 1 second and
5 down during 3 seconds in an asymmetric sinusoidal manner. The length of stroke was 9 cm. The stationary screen had passages of 0.5 mm square, with 100 passages per cm².

Fig. 2 shows that despite the small difference in density a separation can be achieved very quickly. The pictures a - d were taken within a timespan of 2 min.
10

Example 2

In this experiment, an apparatus as depicted in fig. 3 was used having a sieve 4 made of bars providing slit-like
15 openings (width 6 mm, length several cm). Facilitating particles were used having a density of 970 kg/ m³, a length of 8-12 mm, a diameter of 8 mm and in an amount equivalent to two layers, to separate flakes of PP (density approximately 900 kg/ m³) and HDPE (density approximately 950 kg/m³). Condi-
20 tions: frequency 10/minute; length of stroke: 45 mm; screen section 4a 300 mm, screen section 4b 50 mm. Screen width: 200 mm. Separation occurs in a period of 1-2 minutes. The PE obtained was almost pure (less than 1% PP). PP still comprised about 10% PE, which is still a significant improvement over
25 the original 50/50.

CLAIMS

1. Method of separating particles in a fluid medium having a density higher than that of the particles to be separated, whereby a mixture of the particles to be separated is fed to a separation chamber of a separation apparatus, and
5 streams enriched in a particular type of particles are discharged from the separation chamber, characterized in that the mixture of particles is subjected to a treatment comprising the step of moving the fluid medium up and down relative to the mixture of particles, whereby a barrier is present
10 above the particles for restraining the particles.

2. Method according to claim 1, characterized in that the particles to be separated are plastic particles.

3. Method according to claim 2, characterized in that the plastic particles to be separated are polyolefines.

15 4. Method according to any of the preceding claims, characterized in that the fluid medium is an aqueous medium.

5. Method according to claim 4, characterized in that the aqueous medium is water.

20 6. Method according to claim 4 or 5, characterized in that the aqueous medium has a temperature of about 0°C.

7. Method according to any of the preceding claims, characterized in that separate discharge-facilitating particles are present in the fluid medium.

25 8. Method according to claim 7, characterized in that facilitating particles are bulky particles having a density between the densities of the streams enriched in particular particles.

30 9. Method according to any of the preceding claims, characterized in that the barrier for restraining the particles is an element provided in the separation chamber.

10. Method according to any of the preceding claims, characterized in that the element for restraining the particles comprises passages for the passage of the fluid medium.

35 11. Method according to any of the preceding claims, characterized in that the element is provided at an angle

with the horizontal, preferably at an angle between 2 - 45°, more preferably between 5 - 30° such that the particles are transported away from the place of supply.

12. Apparatus suitable for separating particles having a density lower than that of a fluid medium, characterized in that the apparatus comprises a separation chamber having a supply opening for particles to be separated and an element is provided above the supply opening for retention of particles, which apparatus is further provided with means for moving a fluid medium up and down relative to the particles to be separated.

13. Apparatus according to claim 12, characterized in that the element possesses passages for the passage of fluid medium.

14. Apparatus according to claim 12 or 13, characterized in that the element is provided at an angle with the horizontal, preferably an angle between 2 - 45°, more preferable between 5 - 30.

15. Apparatus suitable for separating particles having a density lower than that of a fluid medium, characterized in that the apparatus comprises a separation chamber having a supply opening for the particles to be separated said supply opening extending in a substantially radial direction and an element is provided above the supply opening, said element comprising a multitude of openings allowing the passage of said particles, first means are provided to move the fluid medium up and down relative to the particles to be separated and second means are provided to rotate the element relative to fluid medium in the separation chamber.

16. Apparatus according to claim 15, characterized in that it comprises means for locally disturbing a mass comprising added particles not capable of passing through the openings of said element and particular particles separated from particles which have passed through said openings of said element.

17. Method of separating particles in a fluid medium having a density higher than that of the particles to be separated, characterized in that an apparatus according to

claim 15 is used, a mixture of particles to be separated is supplied below a layer of particles having a thickness which doesn't allow them to pass through the openings of the element, the fluid medium in the separation chamber is rotated
5 relative to the element, the element is moved up and down to move the fluid medium relative to the particles to be separated, causing particles with lower density to pass through the facilitating particles and through the openings in said element to end up in fluid medium above said element from
10 which the particles are discharged from the separation chamber, whereas the facilitating particles act as a barrier for and restrain the particles with higher density, which particles with higher density are discharged from the separation in the fluid medium below said element.

15 18. Method according to claim 17, characterized in that the fluid medium is rotated with respect to the wall of the separation chamber.

19. Method of separating particles in a fluid medium having a density higher than that of the particles to be
20 separated, characterized in that an apparatus according to claim 16 is used, a mixture of particles to be separated is supplied below a layer of particles having a thickness which doesn't allow them to pass through the openings of the element, the fluid medium in the separation chamber is rotated
25 relative to the element, the element is moved up and down to move the fluid medium relative to the particles to be separated, causing particles with lower density to pass through the facilitating particles and through the openings in said element to end up in a first section comprising fluid medium
30 above said element from which first section the particles are discharged from the separation chamber, whereas the facilitating particles act as a barrier for and restrain the particles with higher density, the means for locally disturbing the mass of facilitating particles and restrained particles
35 with higher density, allowing said particles with higher density to pass through the openings in said element to end up in a second section above the element separated from the first section and discharging a stream enriched in particles

having a higher density from the separation chamber.

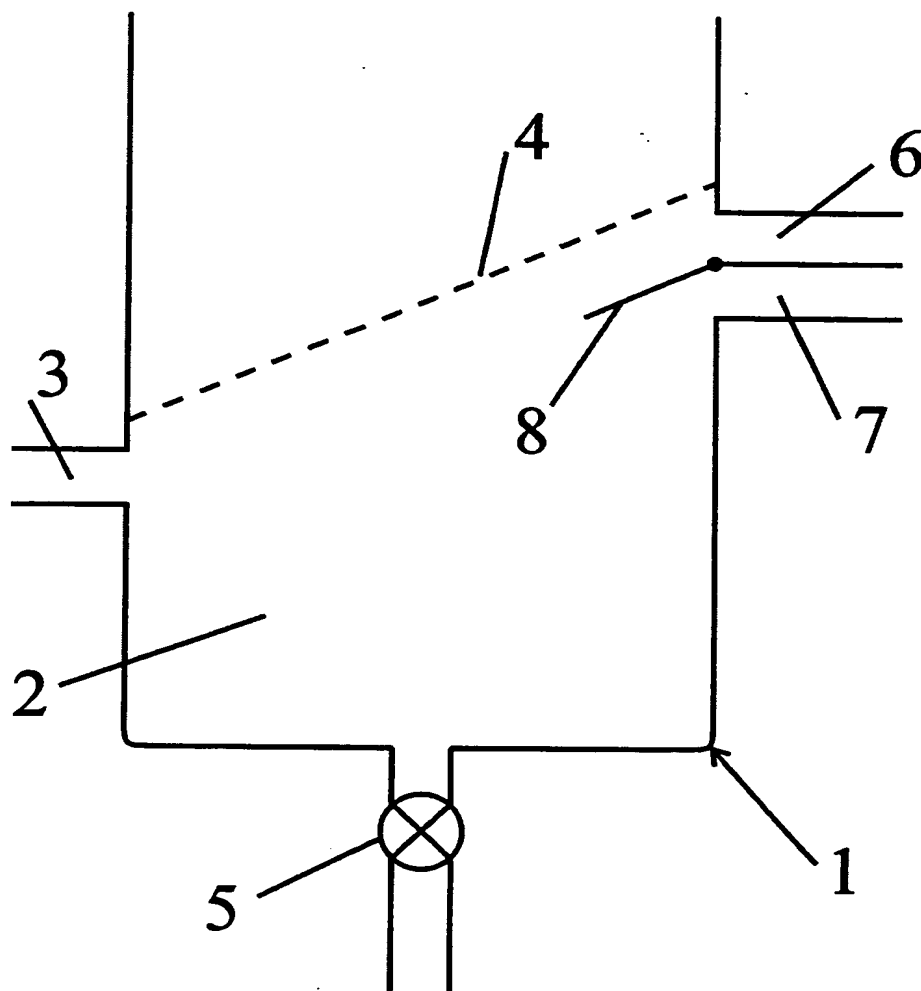
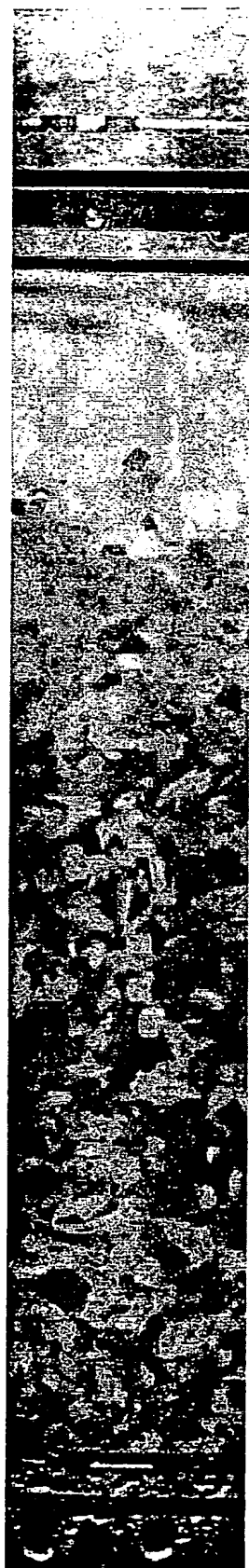


FIG.1



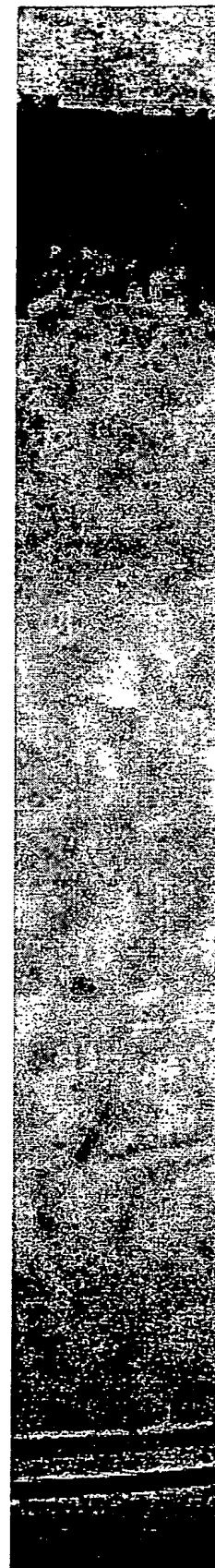
a



b



c



d

Fig. 2

Fig. 3

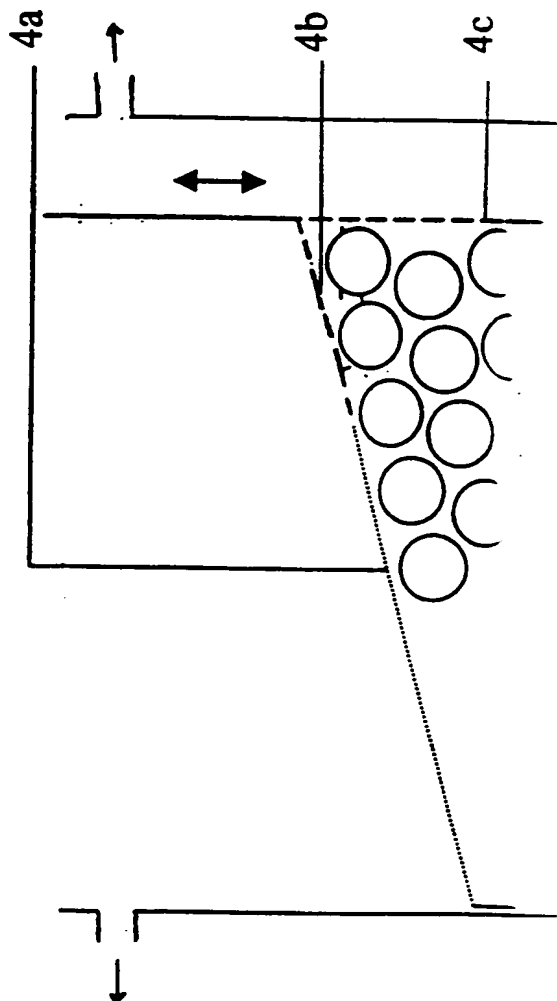
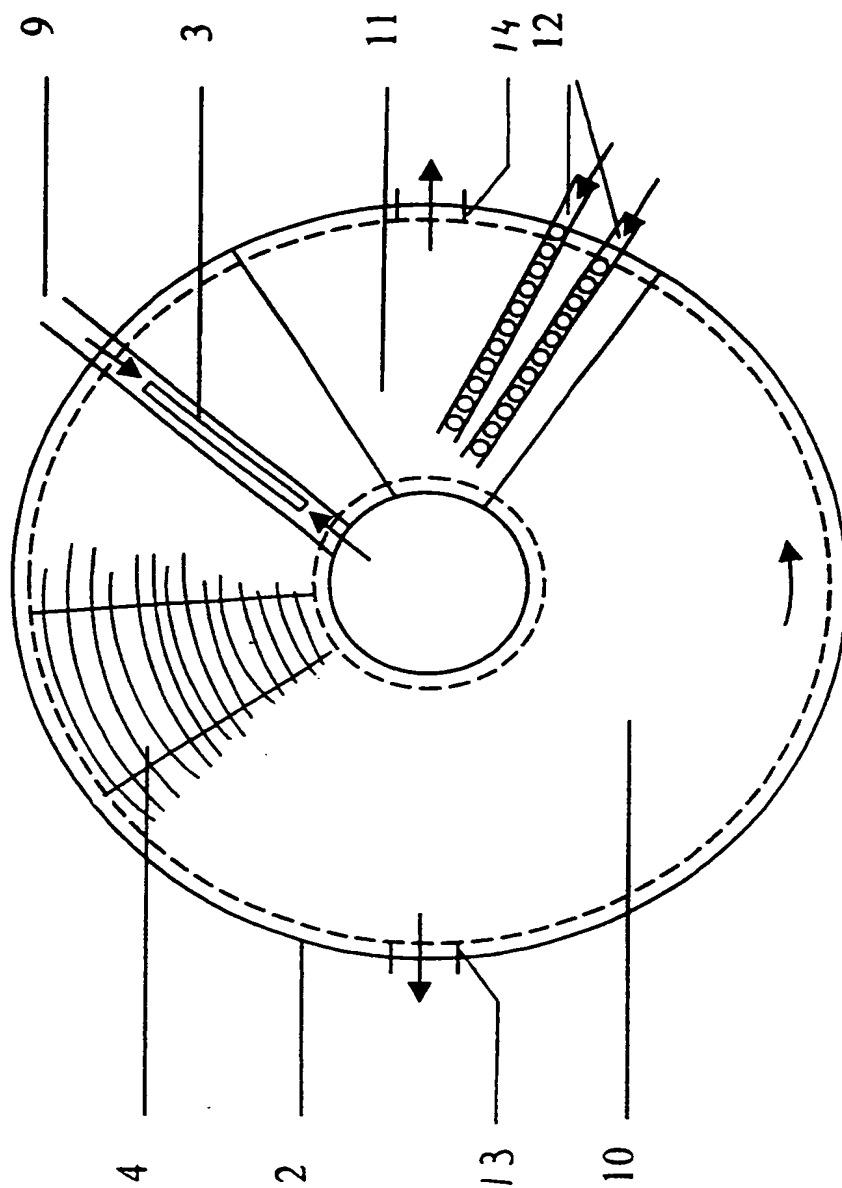


Fig. 4



INTERNATIONAL SEARCH REPORT

International Application No

PC 00/00659

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B03B5/10 B29B17/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B03B B29B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2 708 032 A (M.D. HEYMAN) 10 May 1955 (1955-05-10)	12-14
Y	the whole document	1-5, 9-11, 15 17, 19
A		
Y	DE 43 04 726 A (M. SIEBERT) 18 August 1994 (1994-08-18)	1-5, 9-11
	the whole document	
Y	US 4 772 384 A (K. SCHÖNERT) 20 September 1988 (1988-09-20)	15
A	column 6, line 67 -column 7, line 28 abstract; figures	1, 12, 16-19

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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents:

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
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T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

G document member of the same patent family

Date of the actual completion of the international search

4 December 2000

Date of mailing of the international search report

11/12/2000

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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: REM et al.

Application No.

Examiner:

Filed: (Herewith)

Group Art Unit:

International Application No. PCT/NL00/00659

For: METHOD OF SEPARATING PARTICLES IN A FLUID MEDIUM AND AN
APPARATUS THEREFOR

COPY OF INTERNATIONAL APPLICATION


Box Patent Applications
Commissioner for Patents
Washington, D.C. 20231

Sir:

Attached is a copy of international application No. PCT/NL00/00659 as published, of which the present application forms the national stage. Please note that the claims of the application were amended during international preliminary examination, and that examination of the present application should be carried out on the claims as amended and not on the claims as originally filed.

Respectfully submitted,

Date: 3/15/02


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Docket No. 6900-14

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: REM et al.

Application No.

Examiner:

Filed: (Herewith)

Group Art Unit:

International Application No. PCT/NL00/00659

For: METHOD OF SEPARATING PARTICLES IN A FLUID MEDIUM AND AN
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COPY OF ANNEXES TO INTERNATIONAL PRELIMINARY EXAMINATION REPORT

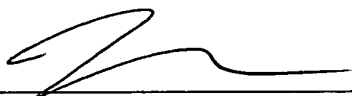
Box Patent Applications
Commissioner for Patents
Washington, D.C. 20231

Sir:

Attached is a copy of the annexes to the international preliminary examination report for international application No. PCT/NL00/00659 as published, of which the present application forms the national stage. Examination of the application should be based on the claims presented in the following pages, duly amended by the preliminary amendment attached hereto.

Respectfully submitted,

Date: 3/15/02



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